PCT/GB 2004/003194

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Dated 25 April 2006

Patents Form 1/77

Patents Act 1977
(Rule 16)

1/77

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

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1. Your reference	PF41/IB/jar	
2. Patent application number *(The Patent Office will fill in this part)*		0317104.8
3. Full name, address and postcode of the or of each applicant *(underline all surnames)* 08105488001 Patents ADP number *(if you know it)* If the applicant is a corporate body, give the country/state of its incorporation	Polatis Ltd 25 Cambridge Science Park Milton Road Cambridge CB4 0FW	
4. Title of the invention	FAST PIEZO SCANNERS	
5. Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* Patents ADP number *(if you know it)*	i.p.21 Limited Norwich Research Park Colney NORWICH NR4 7UT 08060758001	

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	0
Description	~~4~~ 2
Claim(s)	0
Abstract	0
Drawing(s)	~~0~~ 2.

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*

Request for preliminary examination and search *(Patents Form 9/77)*

Request for substantive examination *(Patents Form 10/77)*

Any other documents *(please specify)*

11. I/We request the grant of a patent on the basis of this application.

Signature ip21 limited by IB Date 22/07/03

12. Name and daytime telephone number of person to contact in the United Kingdom IAN BISHOP 01603 457008

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

Fast Piezo Scanners

A. Dames Polatis Ltd 18 July 2003

For laser pointing in entertainment, industrial laser marking and scientific (eg biological sample fluorescence measurement) applications, the conventional approach is to use galvanometers. These are single axis rotation devices attached to a mirror. Manufacturers include Cambridge Technology (MA, USA), ScanLab Gmbh (Germany). The devices are relatively large, power hungry when scanning fast, and limited in bandwidth. To do 2 axis scanning, the light is bounced off two devices in turn, which as well as adding to complexity, gives disadvantages in many optical systems as the source of the image appears in different places in X and Y planes. Piezo scanners exist (eg Piezo Jena, PI Physike, both Germany), but suffer from small scan angles.

Described here are descriptions of how to make fast, compact wide angle 1D and 2D piezo scanners, giving advantage over prior art in terms of their combination of speed, size and power consumption, especially in compact battery powered applications.

Description, 1D scanner.(fig 1)

Two parallel Mode 31 actuators, active length 25 mm, 2mm x 2mm cross section. Multilayer cofired soft ceramic, layer thickness 30um. Joined firmly to each other at the base. Separated by 0.25 mm. Tops joined by stabilising strip, made from 20 um thick, 1.5mm wide spin melt ribbon (eg Vacuumschmelze 6025).

The drive ends of the piezos are connected to the mirror via a parallel flexure pair of 20 um spin melt ribbon, separated by 0.25 mm. To minimise distance of the mirror from the effective rotation point these flexures are short (~ 0.3 mm)

Tops of actuator move +/- 15 um relative to each other for –15 to + 90 Volt (+3,- 0.5MV/m) drive to piezos. Gives an angular displacement of +/- 0.06 radian, and an optical beam swing in reflection off the mirror of +/- 0.12 radian, or 14 degrees pk-pk

The mirror is small and thin, 1.5 by 1.5 mm, 0.13 mm thick metalised glass. Mounted parallel to and overlapping with the flexures, again minimising its inertia about the rotation point.

First resonant frequency of the structure in its operating mode is 28kHz, and can be mounted from the base where the two actuators join with very low coupling of vibration and noise due to the differential drive of the device.

Spurious lower frequency resonance modes are avoided by the symmetry and balanced drive nature of the structure, together with the stabilising flexure connecting the ends of the actuators together, which due to its short length(0.25mm) is extremely stiff in X and Y displacement, but compliant in the operating direction.

Alternatives / variations

Larger displacements can be obtained by reducing the gap between the flexures (eg 0.4 radian pk-pk of the optical beam with 0.125 mm separation).

Mirror can alternatively be mounted flat above the flexure set (need to keep the flexure attach length short)

Smaller cross section piezos can be used (eg 1mmx1mm), giving lower electrical power consumption and a higher average operating velocity (limited by heating of the PZT - heat can escape the thinner piezos faster). Increase further by cooling piezos via fan.

Description, 2D scanner (fig 2)

Actuators same as in the 1D scanner, but uses three parallel devices attached firmly together at their root. Flexure to drive mirror comprises 3 spring steel wires, 125 um diameter, 0.6 mm long on a 1 mm side triangle, one wire attached to the top of each piezo actuator. Mirror mounted flat on top of the ceramic plate that the wires are bonded into (using 3 130 um laser cut holes). Mirror dimension 3mm diameter Optical pk-pk beam swing reflected off mirror 60 mrad or 3. 5 degrees in both X and Y. First resonant frequency 5kHz.

Balanced drive in both X and Y used to avoid transmission of vibration from mounting at root: PZT1 drive= X+Y/2, PZT2 drive= -X+Y/2, PZT 3 drive = +Y.

Alternatives / variations

Add stabilising flexures connecting tips of piezo actuators.

Use stacked and crossed 1D flexure sets (see fig 3). This has advantage of stiffer flexures(as only have to bent in one plane. Illustrated Y axis flexures stacked on top of X axis flexures. Best (for highest resonant frequency) arrangement is that the X axis flexures run downwards back toward PZT root (pair of these on both sides), and the Y axis flexures run back up to the mirror. This keeps the flexure rotation points in the same plane avoiding vignetting issues in other parts of any optical system the scanner is used in, and keeps the mirror plane close to the rotation point (minimises inertia), and maximises useful mirror area.

Fig 1: 1 D scanner

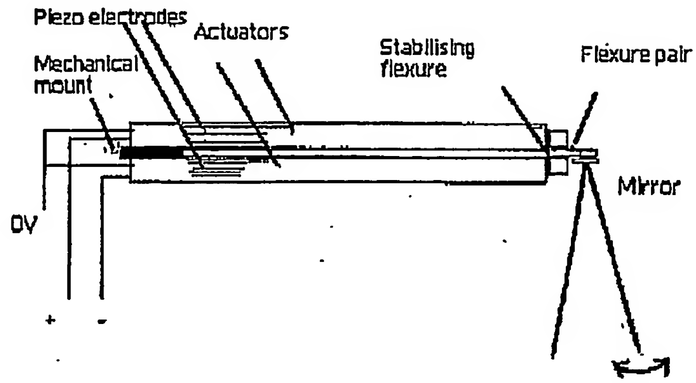


Fig 2. 2D scanner

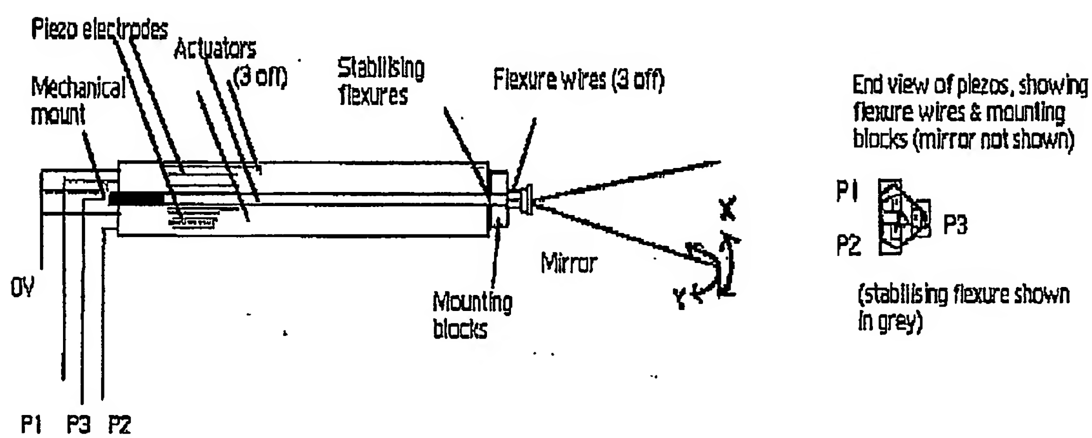
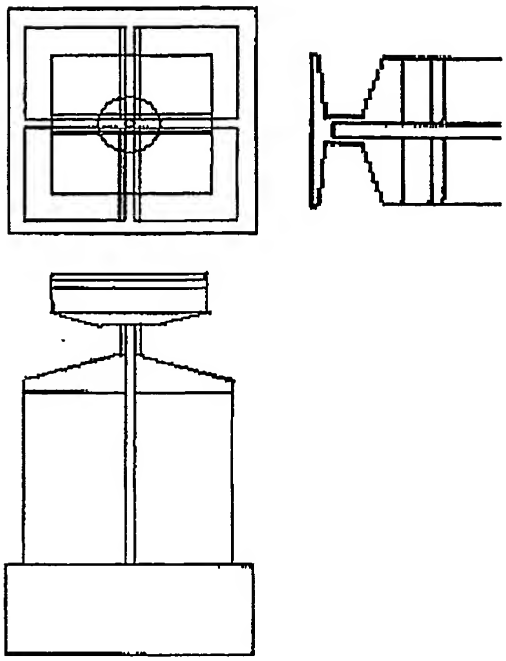


Fig 3 Stacked 1D actuators



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